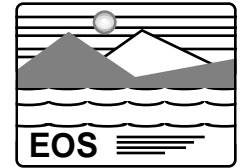




## **EOS AM-1 Mission Operations Review**



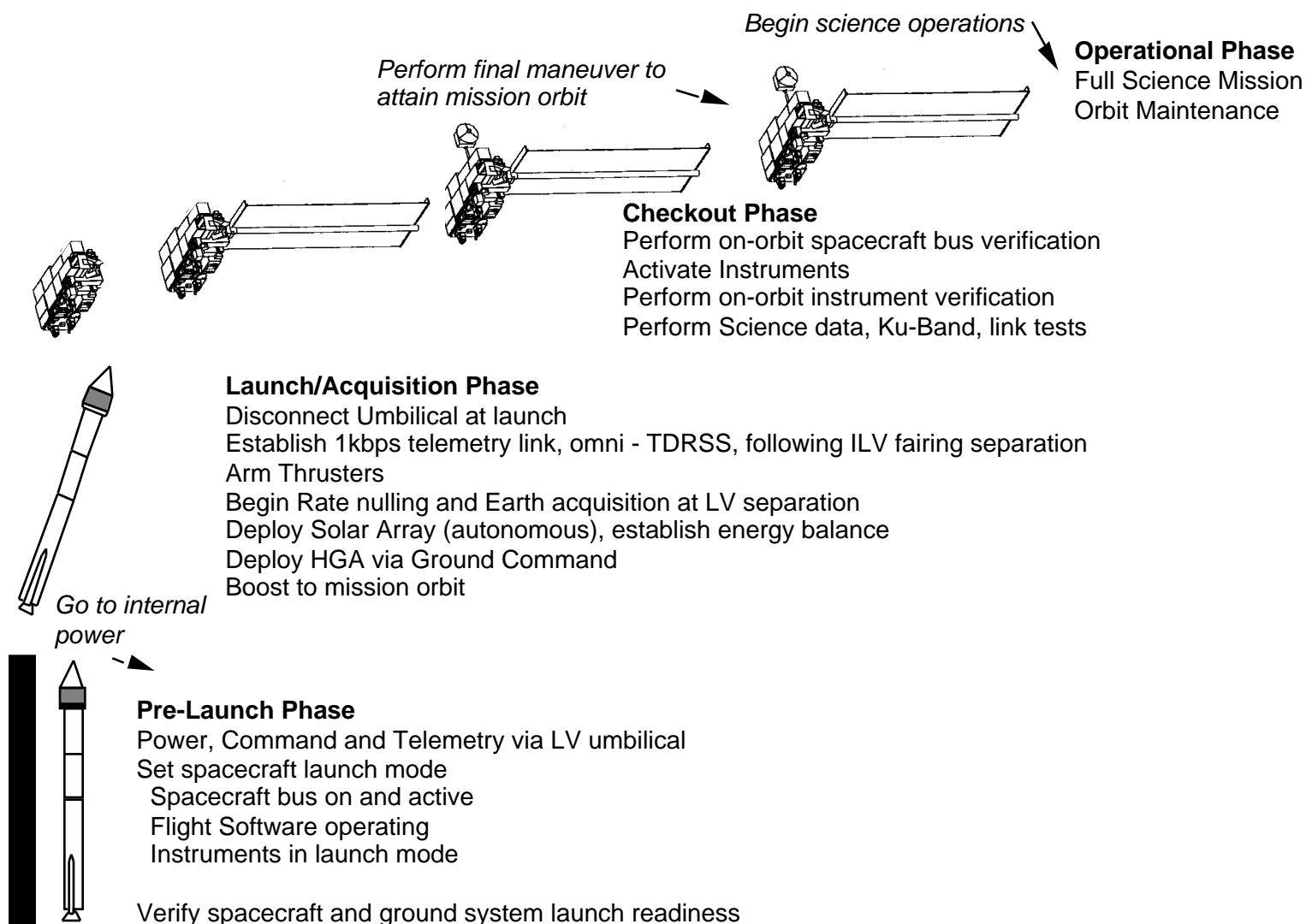
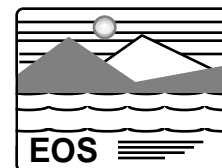
# **EOS AM-1 L&EO OPERATIONS AND SPACECRAFT MANEUVER SUMMARY**

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**Lockheed Martin Missiles and Space**  
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**E-mail: [tford@eos.vf.mmc.com](mailto:tford@eos.vf.mmc.com)**

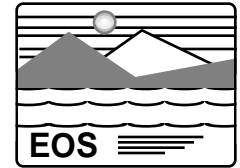


# Mission Phases





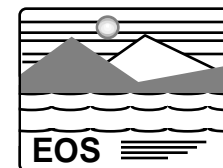
# Launch Configuration – Housekeeping



Subsystem	Launch Configuration	Comments
GN&C	ON: ACE B, Earth sensors 1 and 2, IRUs 1 and 2 (two selected/high rate), RWAs, TAMs, and MTRs OFF: SSSTs, FSS ADAC software in Idle mode NAV FSW in Launch mode	<ul style="list-style-type: none"> <li>Subsystem configured for Earth Acquisition mode processing on receipt of launch vehicle separation.</li> <li>ACE configured for Earth-pointing safehold with thruster control.</li> <li>NAV FSW processing pre-loaded orbit elements.</li> </ul>
PROPS	ACS (1 lbf) thrusters: Disarmed/disabled V (5 lbf) thrusters: Disarmed/disabled Catalyst bed heaters (All): Off Latch valve: Open PMEA 1 (primary): On	<ul style="list-style-type: none"> <li>ACS thrusters to be used for initial rate nulling immediately after separation.</li> <li>Thrusters will be armed and enabled via SCC command on launch vehicle separation.</li> <li>Thrusters will be cold fired.</li> </ul>
C&DH	SCC1(primary): On CTIUs: On BDUs: On SSR (data control unit): On SSR (data memory unit): Off SFE: Off	Subsystems configured for <ul style="list-style-type: none"> <li><u>Command</u> via               <ul style="list-style-type: none"> <li>T0 umbilical until liftoff</li> <li>Omni link after fairing separation</li> </ul> </li> <li><u>Real-time telemetry</u> <ul style="list-style-type: none"> <li>1 kbps via T0 umbilical until liftoff.</li> <li>1 kbps via Omni after transmitter turn on</li> <li>1-kbps H&amp;S via Atlas II/Centaur throughout</li> </ul> </li> <li><u>Recorded telemetry</u> <ul style="list-style-type: none"> <li>16-kbps housekeeping recorded in SSR.</li> </ul> </li> </ul>
COMM	S-band receivers: On S-band transmitters: Off Master oscillator: On DAS components: Off KSA modulators: Off HGA components: Disabled	
SMS	HGA and solar array stowed	
TCS	HCEs: On CPHTS: Off	<ul style="list-style-type: none"> <li>Mechanism deployment during early mission operations</li> <li>Housekeeping heaters available</li> </ul>
EPS	Batteries: Online EPS components: On Array components: Off	<ul style="list-style-type: none"> <li><u>Power</u> <ul style="list-style-type: none"> <li>Via umbilical until L-5 minutes, battery power thereafter.</li> </ul> </li> </ul>



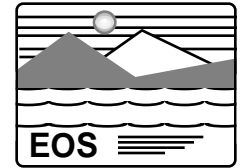
# Launch Configuration – Instrument



Instrument	Launch Configuration	Comments
ASTER	Launch Mode Operational Power: DISABLED Survival/Cooler Power: DISABLED TIR Scanner Latch: ON ___Cooler Latch: ON VNIR Launch Lock: ON SWIR Cooler Launch Latch: ON ___Scan Mirror: Cal Position	<ul style="list-style-type: none"> <li>Power feeds disabled at PDU</li> <li>ASTER desires to enable both operational and survival/cooler power feeds no later than 45 minutes after liftoff.</li> </ul>
CERES	Launch Mode Operational Power: DISABLED CERES Survival Power: DISABLED Elevation Gimbal: STOWED Azimuth Gimbal: CAGED Covers closed	<ul style="list-style-type: none"> <li>Survival power disabled at instrument relay and at PDU.</li> <li>Gimbals in launch position.</li> <li>CERES desires to enable survival no later than 5 hours after liftoff.</li> </ul>
MISR	Launch Mode Operational Power: DISABLED MISR Survival Heaters: DISABLED Covers and mechanisms stowed and latched	<ul style="list-style-type: none"> <li>MISR power feeds enabled at PDU; survival power enabled at instrument relay.</li> </ul>
MODIS	Launch Mode Operational Power: DISABLED Survival Heaters: DISABLED Doors closed and latched	<ul style="list-style-type: none"> <li>MODIS power feeds disabled at PDU.</li> <li>MODIS desires to enable survival power no sooner than 12 hours and no later than 20 hours after separation from launch vehicle.</li> </ul>
MOPITT	Launch Mode Operational Power: ENABLED Survival Power: ENABLED Choppers: ON Length-Modulated Cells: ON Port covers closed and latched	<ul style="list-style-type: none"> <li>Operational power enabled.</li> <li>Rotary choppers and length-modulated cells to be powered OFF and MOPITT Survival mode set 1 minute after separation from launch vehicle.</li> </ul>



# Launch Critical Elements

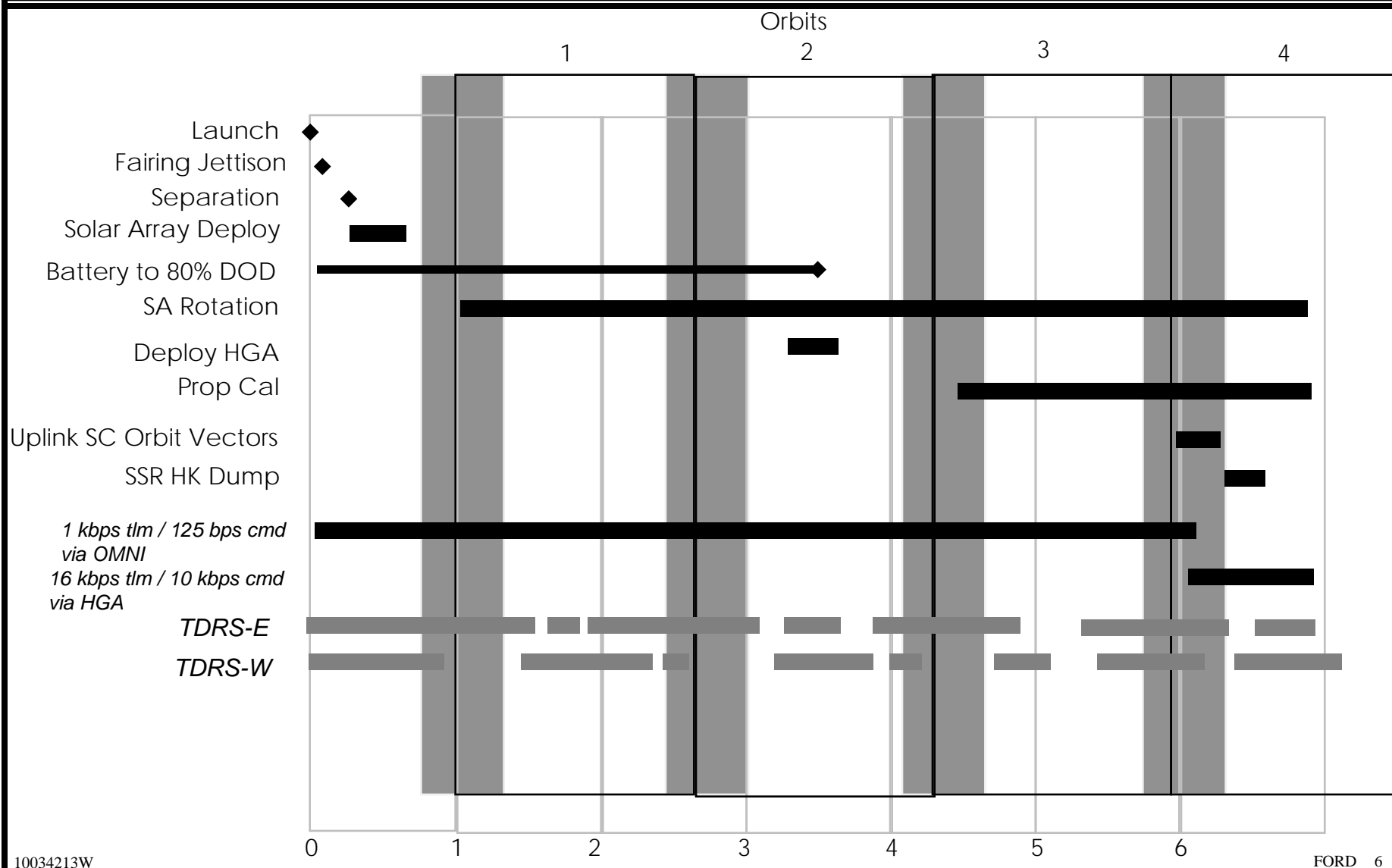
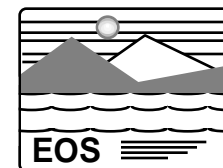


**The following elements are critical for launch:**

- **Launch vehicle (LV)**
  - **Atlas II AS: Ready for launch**
  - **LV GSE: Ready to support LV launch**
  - **TDRS LV Support: Ready for downlink telemetry**
- **Spacecraft**
  - **Spacecraft: Launch mode**
  - **SCS: Ready to support launch**
- **SN/TDRSS: Configured and ready to support S/C Ascent and Early Orbit**
- **Backup Stations: Ready to support emergency S/C Operations (S-band only)**
- **EOC: Configured and ready to support S/C Operations**
- **EDOS: Configured and ready to support EOS AM-1 Telemetry and Command**
- **EBnet: Configured and ready to support EOS AM-1 Flight Operations Communications**
- **FDD: Configured and ready to provide EOS AM-1 Flight Operations Support**

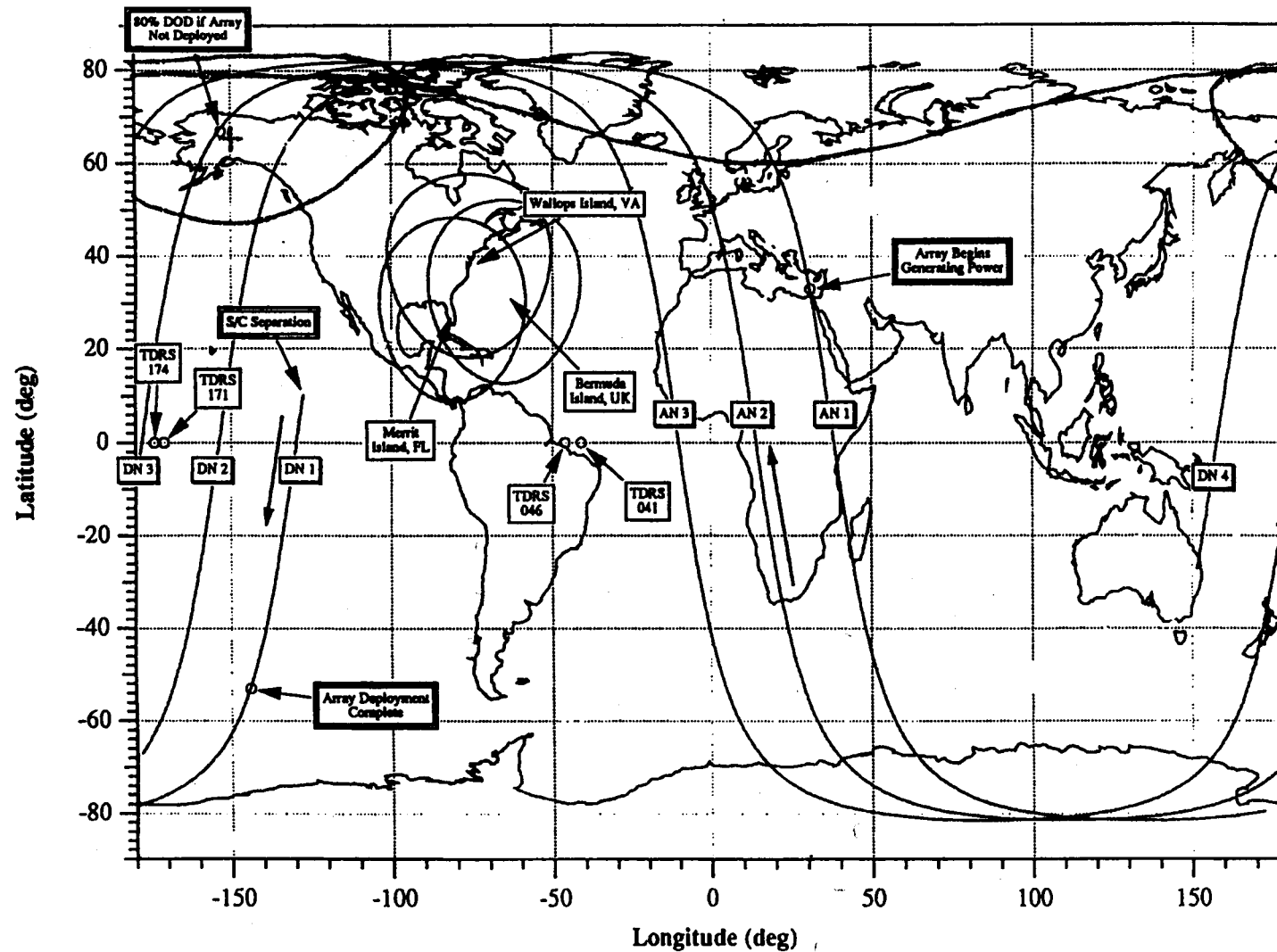
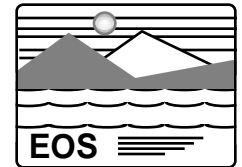


# Early Mission Timeline



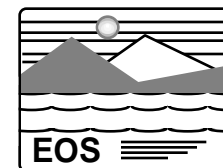


# Early Orbits' Ground Track





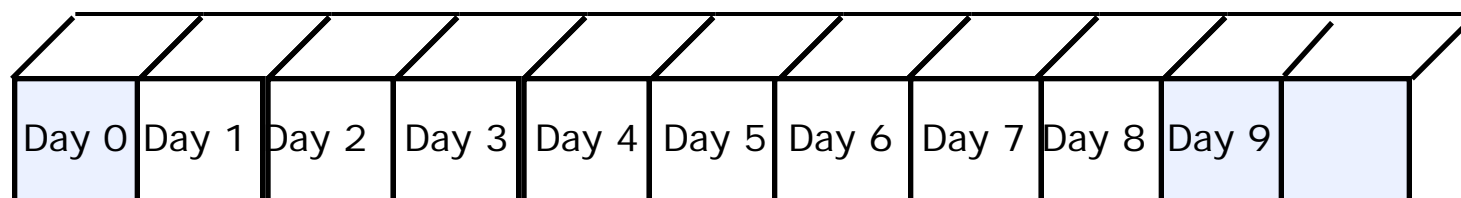
# Launch/Acquisition Phase Operations



Prelaunch  
Phase  
Days: Pre 1

Launch/  
Acquisition  
Phase  
Days: 1 - 9

Checkout  
Phase  
Days 9=>



Orbit Acquisition: Days 4 - 9  
Orbit Acquisition Burns  
Trim Maneuvers  
Achieve Mission Orbit

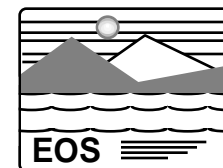
Early Mission Operation Day 1 Rev 0  
Go to Internal Power (L-5:00)  
Liftoff (L)  
Fairing Jettison (L+3:12)  
S-Band Transmitter On (L+7:00)  
Launch Vehicle Separation (L+14:00)  
Earth Acquisition (L+14:00 - 30:00)  
MOPITT Power Commands (L + 15:00)  
Solar Array Deployment (L + 16:00 - 32:00)  
Command Link Establishment (L + 24:00)  
HGA/Instrument Power Commands (L+35:00)  
Array Rotation Commanding (L+ 58:00)

Transfer Orbit Operations Days 1 -3  
MODIS Power Enabled  
HGA Deployment  
HGA Gimbal Checkout  
HGA Communications Check out  
Playback Launch Ascent Telemetry  
Propellant Gauging  
Orbit elements and stored commands for HGA pointing





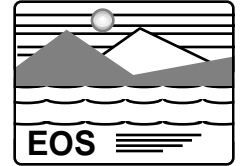
# Early Mission Timeline – Day 1



Orbit	Nominal Times	Key Events	Notes
Pre - 0	L - 5:00 Launch L + 3:12 L + 7:00 L + 14:00	Set launch configuration Go to internal power Liftoff Fairing separation S-band transponder turned ON Launch vehicle separation	<ul style="list-style-type: none"> <li>• <u>Power</u> via umbilical until L-5; battery power thereafter</li> <li>• <u>Command</u> via T-0 umbilical until liftoff via Omni link after transponder turn on.</li> <li>• <u>Telemetry</u> 1 kbps via T0 umbilical until liftoff, 1 kbps via Omni after fairing separation; 1 kbps housekeeping via Atlas II/Centaur throughout.</li> </ul>
0	L + 14:00 L + 14:03 - 30:00 L + 15:00  L + 16:00 - 32:00 L +24:00 L +35:00 L +35:00 L +40:00 -1:15:14 L +58:00	Separation signal received Earth acquisition MOPITT LMCs and choppers OFF; set Survival mode Solar array deployment Command link checkout Instrument power supplied HGA power supplied First eclipse Initiate solar array open loop tracking (1 w)	<ul style="list-style-type: none"> <li>• Earth acquisition uses thrusters for initial rate nulling only; reaction wheels thereafter.</li> <li>• MOPITT LMCs and choppers on through ascent. Solar array deployment uses nonexplosive actuators.</li> <li>• ASTER/CERES/MOPITT and HGA supplied with power for Survival mode heaters.</li> </ul>
1		Electrical power subsystem status checkout	<ul style="list-style-type: none"> <li>• EPS checkout after eclipse for first 10 orbits.</li> </ul>
2	L +3:20:00 - 4:00:00 L +4:00 - 4:20	Transmit launch ascent telemetry HGA deployment and checkout Propellant volume calibration initiation	<ul style="list-style-type: none"> <li>• HGA gimbal test and link establishment.</li> <li>• Recorded housekeeping telemetry playback (HGA/TDRS SSA).</li> </ul>
3	L + 4:30	EPS status checkout	<ul style="list-style-type: none"> <li>• Propellant volume calibration to meet propellant estimation requirement (24 hours).</li> </ul>
4 - 10		EPS status checkout	<ul style="list-style-type: none"> <li>• EPS checkout after eclipse for first 10 orbits.</li> </ul>
7	L + 12:15:00	MODIS power enabled	<ul style="list-style-type: none"> <li>• MODIS supplied with power for Survival mode heaters approximately 12 hours after separation.</li> </ul>



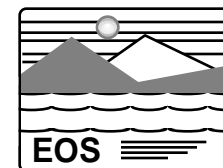
# Orbit Acquisition



- Orbit acquisition maneuvers to raise spacecraft from Atlas II AS separation orbit (~690 x 550 km altitude) to mission orbit (705-km circular)
- Nominal scenario
  - Four large (15-minute) Delta-V burns using two 5-pound thrusters, burns centered at apogee to raise perigee to near-mission altitude
  - Large maneuvers to include initial yaw attitude offsets, of up to  $\pm 20$  degrees, sufficient to remove launch vehicle inclination dispersions
  - Several small (trim) maneuvers performed as necessary to achieve mission orbit
  - Maneuvers are not time critical
    - » FDD to plan and coordinate maneuvers
    - » Nominal schedule is to perform one large burn per day
    - » Burns scheduled to occur starting on third day



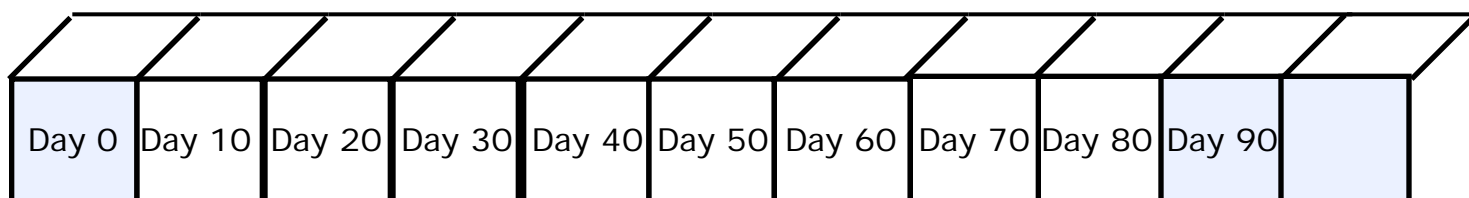
# Housekeeping Checkout Phase Operations



Launch/  
Acquisition  
Phase  
Days 1 -9

Checkout  
Phase  
Days 9 - 90

Operational  
Phase  
Days 90 =>



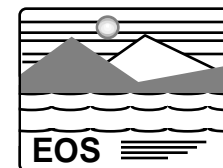
Days 40 -50  
ADAC Long-term Checkout Complete  
TONS Long-term Checkout Complete  
Orbit Maintenance Maneuver

Days 10 - 20  
GN&C Sensor Calibrations  
ADAC Normal Mode Initial Checkout  
TONS Normal Mode Initial Checkout  
Ku-Band Link Checkout  
DAS X-Band Checkout  
HGA (Ku-Band) Gimbal Calibration

Day 9  
ADAC Normal Mode Initialization  
TONS Normal Mode Initialization  
CPHTS Turn on



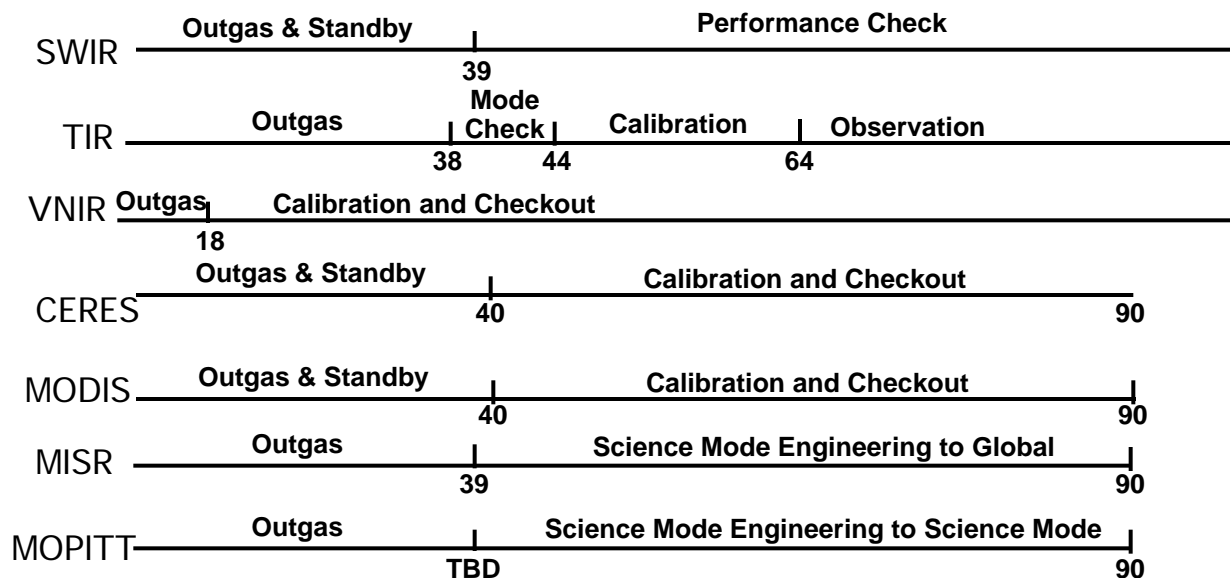
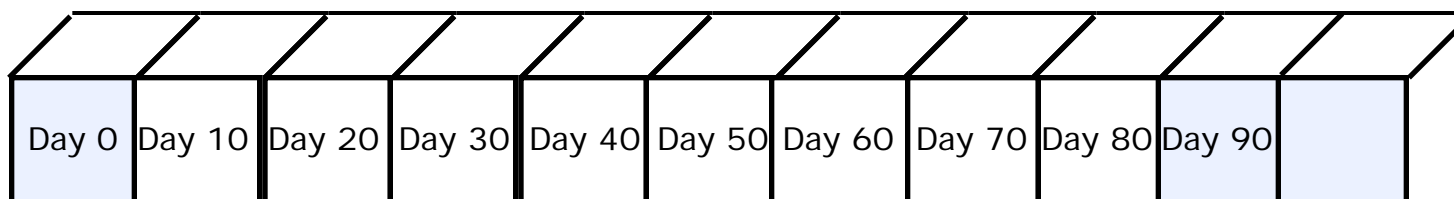
# Instrument Checkout Phase



Launch/  
Acquisition  
Phase  
Days 1 -9

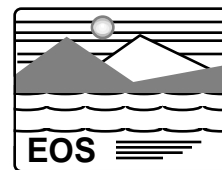
Checkout  
Phase  
Days 9 - 90

Operational  
Phase  
Days 90 =>





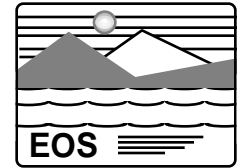
# EOS AM-1 Mission Profile



- **EOS AM-1 mission orbit**
  - **Sun-synchronous and frozen orbit**
    - » 705 km  $\pm$ 5 km                      Mean equatorial altitude
    - » 98.2 deg  $\pm$ 0.15 deg              Inclination
    - » 90 deg  $\pm$ 20 deg                  Argument of perigee
    - » 0.0012  $\pm$ 0.0004                  Eccentricity
  - Descending node 10:15 to 10:45 a.m. local mean solar time (LMST)
  - 233 orbit ground track repetition interval (16 days)
  - $\pm$ 20-km ground track repetition accuracy at all latitudes
  - Frozen orbit:  $\pm$ 5-km radial orbit position repeatability at all latitudes
- **EOS AM-1 injection orbit**
  - 689.9 km  $\pm$ 7.0 km                      Separation apogee altitude
  - 551.4 km  $\pm$ 2.5 km                      Separation perigee altitude
  - 98.224 deg  $\pm$ 0.1 deg                  Inclination



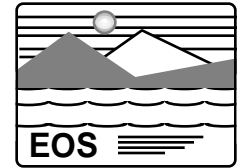
# EOS AM-1 Spacecraft Maneuver Summary



- **EOS AM-1 maneuvers required to support mission**
  - **Orbit acquisition maneuvers** raise spacecraft from Atlas II AS separation orbit (~690 X 550-km altitude) to mission orbit
    - » Four large (15-minute) Delta-V burns using two 5-pound thrusters, burns centered at apogee to raise perigee to near-mission altitude
    - » Large maneuvers to include initial yaw attitude offsets (up to  $\pm 20$  degrees) sufficient to remove LV inclination dispersions
    - » Several small (trim) maneuvers performed as necessary to achieve mission orbit
  - **Orbit maintenance maneuvers**
    - » **Maintain descending node LMST**
      - Periodic inclination maneuvers
      - Requires initial 90-degree yaw attitude slew before and after out-of-orbit plane Delta-V burn
    - » **Maintain ground track**
      - Altitude correction (drag makeup) maneuvers
      - Performed weekly to monthly, as dictated by solar activity, small in-plane Delta-V maneuvers of <1 minute each
      - One burn per orbit



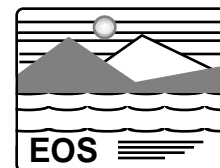
# EOS AM-1 Spacecraft Maneuver Summary (Cont'd)



- » **Maintain frozen orbit**
  - Period eccentricity vector corrections performed as required
  - Plan is to perform coincident with drag makeup maneuvers
  - May be performed occasionally as two drag makeup burns spaced about orbit
- **CERES yaw maneuver**
  - » Necessary to quantify partial blockage of CERES solar calibration FOV
  - » Maneuver duration approximately 15 minutes once or twice per year after initial checkout
  - » Yaw slew of up to 11 degrees based on solar beta angle
  - » Reaction wheels will be used; not a thruster maneuver
- **GN&C sensor calibration maneuvers being evaluated; could require slews on the order of 20 degrees during checkout phase operations**
- **Other science-driven maneuvers under evaluation**
- **Maneuver planning**
  - Maneuvers will be planned by GSFC FDD
  - Maneuver predicts 7 weeks before event
  - Final burn plans 4 to 24 hours in advance
  - Maneuvers are not time critical; afford flexibility in scheduling instrument activities (e.g., MODIS field activity) and TDRSS coverage



# EOS AM-1 Maneuver Summary

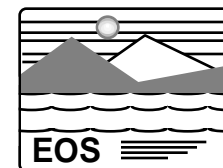


	Orbit Acquisition	Orbit Maintenance Drag Makeup	Orbit Maintenance Inclination Correct	CERES Yaw Slew
Thrusters Used Frequency	YES 6 or 7 during orbit acquisition	YES Weekly to monthly	YES 1 or 2	No 4 to 6 first 3 months; 1 to 2 per year thereafter
Constraints	Dependent on injection orbit	1 or 2 burns located to maintain frozen orbit	Equator Crossing Nominally during eclipse	North Pole region; beta angle dependent
Attitude Maneuver	15- to 20-degree yaw slew before and after large V burns using thrusters	None	~90-degree yaw slew before and after V burn using thrusters	0- to 11-degree yaw axis slew for of 24 to 13 degrees for ~15 minutes using reaction wheels
Attitude Burn Time	2 minutes each way	N/A	10 minutes each way	N/A
V Burn Time	4 burns of 15 minutes; 2 to 3 burns of 1 minute	<1 minute	10 to 15 minutes	N/A
Time to Attitude Recovery (Science Accuracy)	N/A	10 minutes	1 to 2 orbits (3 hours) (depends on need for filter reconvergence)	0 minute
Time to Navigation Recovery (Science Accuracy)	N/A	Science requirements should be maintained (return to preburn accuracy in 1 hour after each burn)	6 to 24 hours (dependent on postmaneuver TDRS schedule and NAV FSW configuration)	Science accuracy maintained
Coverage	TDRS and ground required for first burns; TDRS desired/expected thereafter	During: TDRS desired/expected After: Two NAV contacts per burn, each 1/2 orbit apart	During: TDRS desired/expected After: NAV contacts to both TDRS 1/2 orbit apart for 6 hours	During: TDRS desired/expected





# EOS AM-1 Maneuver Summary



Instrument Activities			
Instrument	Orbit Acquisition	Orbit Maintenance Drag Makeup      Orbit Maintenance Inclination Correct	CERES Yaw Slew
ASTER	Launch configuration heater and operational power enabled	Pre maneuver : Transition from Standby mode to Contamination Safe mode in approximately 10 minutes. Component on/off as in Standby mode, mirrors positioned to cal positions . Post maneuver : Transition from Contamination Safe mode to Standby mode. SWIR mirror returned to operational position (approximate 10-minute recovery) .	Normal Operations
CERES	Launch configuration heater power enabled	Contamination Safe mode -- Boresights moved to safest orientation; covers remain open. Maximum azimuth gimbal slew time approximately 15 seconds.	Solar calibration
MISR	Launch configuration heater power enabled	Safe mode -- calibration plates stowed, covers closed	Normal Operations
MODIS	Launch configuration heater power enabled	Transition to Standby mode; solar diffuser door closed	Normal operations ; flagged data
MOPITT	Launch configuration heater power enabled	Drag makeup maneuvers -- Short-term cal Inclination correct -- Long-term cal	Short-term cal